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BREEDING DENSITY AND LANDSCAPE-LEVEL HABITAT SELECTION OF COMMON BUZZARDS (*BUTEO BUTEO*) IN A MOUNTAIN AREA (ABRUZZO APENNINES, ITALY)

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ABSTRACT.—The breeding density and landscape-level habitat selection of Common Buzzards (*Buteo buteo*) was studied from 1989–93 in a mountain area of Abruzzo Apennines (central Italy). Analysis of landscape features was based on circular plots (2.5 km diameter) centered on occupied nest trees. A total of 32 Common Buzzard nesting territories were identified within a 387 km^2 area (8.3 pairs/100 km^2, mean nearest-neighbor distance 2.5 km). The average altitude of the nest sites was 1399 m above sea level and 73.1% were oriented NE. Stepwise discriminant function analysis showed significant differences between nesting ($N = 17$) and control sites ($N = 15$) based on four landscape variables: relief index, distance from forest edge, distance from paved road and distance from valley bottom. Results suggest that Common Buzzards select nesting areas in the eastern portion of forests which are distant from roads but close to valley bottoms, in rugged areas of irregular morphology.

KEY WORDS: *Common Buzzard; habitat selection; landscape-level; breeding density;* Buteo buteo.

Densidad de cría y selección niveles de paisaje hábitat en *Buteo buteo*

RESUMEN.—La delicadeza de cría y nivel del paisaje, selección del hábitat del *Buteo buteo* fue estudiado de 1989–93 en un área de montaña de Abruzzo Apennines (central Italy). Análisis del elementos del paisaje estuvo basado en lugares círculos (2.5 km diámetro) centrado en nidos de árbol ocupados. Un total de 32 *B. buteo* territorios de nido fueron identificados dentro de 387 km2 área, (8.3 pares/100 km^2, media cerca-vecino distancia 2.5 km). El altitud regular de los nidos fue 1399 m arriba del mar y 73.1% fueron orientados NE. Una función discriminante de pasos enseño un análisis con diferencias significas entre nidos ($N = 17$) y sitios de control ($N = 15$) basados en cuatro paisajes variados: relevo indicie, distancia de la orilla del bosque, distancia del camino pavimentado y distancia del fondo del valle. Resultados Sugieren que el *B. buteo* selecciona áreas de nidos en lugares este en el bosque donde están muy lejos de caminos pero mas cerca al fondo del valle, en áreas toscas de morfología irregular.

[Traducción de Raúl De La Garza, Jr.]

Nest-site preferences have been described for the Common Buzzard (*Buteo buteo*) (Tubbs 1967, Glutz von Blotzheim et al. 1971, Tubbs 1974, Arce Velasco 1987, Taylor et al. 1988), but few studies have attempted to quantitatively determine the factors involved in nest-site selection at a landscape level (Newton et al. 1982, Jedrzejewski et al. 1988, Kostrzewa 1989, Hubert 1993, Hohmann 1994, Graham et al. 1995, Cerasoli and Penteriani 1996). All of these studies have analyzed nest-site selection at a microhabitat level (nest-tree characteristics and stand structure) without considering the possible effects of landscape structure. In this paper, we present a landscape-level analysis of Common Buzzard nest sites, which was conducted to identify the landscape determinants of nest-site selection.

METHODS

A population of Common Buzzards was studied from 1989–93 in a mountain area of central Italy (Abruzzi Apennines). The study covered a 387 km^2 area of beech (*Fagus sylvatica)* forest (typical of the Apennine massifs of the Abruzzi region) that covers the National Park of Abruzzi and the Sirente mountains. Elevation of the area ranges from 1000–2340 m. The landscape has a distinct mosaic structure with large woodland areas and reforested tracts of *Pinus nigra,* cropland, pastures and fallow land from 1000–1800 m elevation.

Occupied nests were located by systematic foot searches of the area prior to leafout. We also used playbacks of recorded Common Buzzard calls during the months of March–April (prelaying period) and June–July (nestling and fledgling periods) (Cerasoli & Penteriani 1992). Areas where a pair of Common Buzzards was observed during the breeding period, but no nest was found, were classified as possible nesting territories (Jedrzejewski et al. 1994). A number of nesting territories were identified by observing adults carrying nesting material, by noting where the displays of males ended with steep dives into the woods (Picozzi and Weir 1974) and from alarm calls of adults and shrill calls of the fledged young.

We used the nearest-neighbor distance method (Newton et al. 1977) to estimate nesting density. Regularity in nest-site spacing was computed with a G-test (Brown & Rothery 1978). Landscape-level analysis of habitat selection only considered those Common Buzzard nest sites where nests had been located. Moreover, all nest sites that changed during the study period due to road building, cutting of forest tracts or changes in farming were excluded from the analysis. Analysis of landscape features was based on circular plots centered on the occupied nest tree. These plots had a diameter equal to the mean distance between neighboring nest sites. Each nest site was characterized using a set of 23 variables: slope exposure, elevation, eight variables describing patch composition of the landscape (percentage of woodlands, pastures, fallow land, fallow land with trees, rocks, crops, crops with trees and built-up patches), three variables for horizontal heterogeneity (number of ecotones, number of different habitats calculated on two orthogonal axes from the plot center and patch interspersion index [habitat changes/plot area] x 100, calculated on two orthogonal axes from the plot center; Baxter and Wolfe 1972), two variables for vertical heterogeneity (maximum difference in elevation and relief index calculated as the sum of the number of contour lines crossed by two orthogonal axes from the plot center; Janes 1985, Litvaitis et al. 1994), and eight variables for distance of nest sites from surrounding landscape components (forest opening, forest edge, valley bottom, built-up area, paved road, pathways, cliffs, permanent water). The number of ecotones, number of habitats and the interspersion relief indexes were sampled on two straight lines oriented N-S and W-E along the plot diameters. Areas of each of the different habitats were determined on the basis of land use maps to a scale of 1:25 000. For each nest site, one control plot was established where we measured the same variables as in nest site plots, except for slope exposure and elevation to estimate landscape selection. Each control plot was centered around a random point located between nest-site plots. To qualify as control plot, the plot had to lie within a forested area. Plots which did not have woodland areas or which had only young plantation areas (where Common Buzzards do not nest) were not included in our analysis (Hubert 1993, Jedrzejewski et al. 1994).

Landscape characteristics of nest-site and control plots were compared by using a stepwise discriminant function analysis (DFA, Sokal and Rohlf 1981). We used the 5% level of significance for including variables in each step of the analysis. The classification of the described sites, obtained with DFA, was tested with Kappa statistic (Titus and al. 1984). The robustness of the nest-site selection model was tested with a jack-knife procedure. We used a chi-square test to analyze the selection of nest-site slope exposure.

RESULTS

Nest-site Density. A total of 26 known and 6 suspected Common Buzzard nesting territories were identified within the 387 km^2 study area, for a density of 8.3 pairs/100 km^2. Mean distance between nesting territories averaged 2.5 km (range = 1.62–4.12 km, SD = 0.54). Within woodland areas, Common Buzzard nesting sites were spaced regularly, as shown by the G-test ($G = 0.96$).

Landscape-level Habitat Selection. The average altitude of buzzard nest sites was 1399 m above sea level (range 1150–1550 m, SD = 131.87). Analysis of nest exposure ($N = 26$) showed that 73.1% ($N = 19$) were oriented NE ($\chi^2 = 33.69$, df = 3, $P = 0.001$), 3.8% ($N = 1$) S and SE, and 19.3% ($N = 5$) SW.

The DFA showed significant differences ($P < 0.05$) between nesting ($N = 17$) and control sites ($N = 15$) based on the four landscape variables relief index, distance from forest edge, distance from paved road and distance from valley bottom (Table 1). We obtained correct classification for 14 of the control sites (93.3%) and 16 of the Common Buzzard nesting sites (94.1%). Conversely, there was one misclassified control site (7%) and one misclassified nesting site (6%). This classification is 87% better than random (Kappa = 0.874, $Z = 4.946$, $P < 0.0001$). The jack-knife classification showed the robustness of the model with 88.2% of the nesting sites and 93.3% of the control sites correctly classified.

DISCUSSION

Common Buzzard nesting density decreases from 8.3 pairs/100 km^2 in the mountain areas of the Apennines, to 19.7 pairs/100 km^2 in the hills in the piedmont, to 32 pairs/100 km^2 in woodlands of low-altitude areas (Manzi and Pellegrini 1989, Manzi et al. 1991). Low nesting densities at higher altitudes is likely due to the scarcity of prey as evidenced by the lower density of birds in high mountain areas (36 pairs/10 ha; Bernoni 1995) than in piedmont (59.2 pairs/10 ha; Pandolfi and Taferna 1991) and plain areas (158 pairs/10 ha; Bernoni et al. 1989). The average nearest-neighbor distance of 2.5 km was also relatively high when

Table 1. Sample means and standard deviations of landscape habitat variables measured at control and nest sites of the Common Buzzard. Significant differences determined by Stepwise Discriminant Function Analysis.

	NESTING SITES (N = 17)	CONTROL PLOTS (N = 15)
Woodland patches (%)	54.5 ± 22.9	40.2 ± 25.3
Pasture patches (%)	24.1 ± 16.1	19.8 ± 11.3
Fallow patches (%)	6.5 ± 5	9.4 ± 5.8
Fallow patches with trees (%)	3.9 ± 4.1	7 ± 7.9
Rocky patches (%)	4.8 ± 6.5	7.1 ± 7.7
Cropland patches (%)	2.7 ± 2.9	3.5 ± 5.6
Cropland patches with trees (%)	3.5 ± 8.5	12.4 ± 14.7
Built-up patches (%)	0 ± 0	0.6 ± 1.3
Number of ecotones	9.8 ± 4.1	16 ± 4.5
Number of habitats	15.5 ± 5.6	20 ± 5.2
Interspersion index	11 ± 2.4	10.5 ± 2.1
Maximum difference in elevation (m)	395.1 ± 165.7	468.3 ± 121.5
Relief index	47.2 ± 12.5	23.2 ± 9.7*
Distance from forest opening (m)	267.6 ± 155.3	179.3 ± 140.9
Distance from nearest forest edge (m)	269.1 ± 239.22	509.3 ± 383.4*
Distance from valley bottom (m)	983.8 ± 487.7	1438.3 ± 845.8*
Distance from built-up area (m)	2827.9 ± 1738.8	2236.7 ± 1049.7
Distance from nearest paved road (m)	1592.6 ± 1224.4	753.3 ± 610.6*
Distance from footpath (m)	613.2 ± 632.1	120 ± 88.2
Distance from cliffs (m)	1376.5 ± 706.8	1128 ± 486.8
Distance from permanent water (m)	1560.3 ± 959.5	885.3 ± 443.2

* $P < 0.05$.

compared with the values of 0.87 and 1.13 km (Newton et al. 1982) 1.04 km (Jedrzejewski et al. 1994) and 1.9 km (Graham et al. 1995) in other areas of Europe.

Our landscape level analysis showed that Common Buzzards did not select habitat at random at a landscape level, as the majority of nest sites (94.1%) and control sites (93.3%) were correctly classified. These results suggest that Common Buzzards select nest sites in the eastern part of forests that are situated on northern slopes. The tendency to use northern slopes may simply be due to the fact that NE facing slopes support the tallest beech trees, but it may also be related to the fact that these slopes provide cooler temperatures and less sunlight, as well as a denser canopy cover that may increase nest protection.

The Common Buzzard is an area-sensitive species that requires forested habitats which are distant from roads but close to valley bottoms in rugged areas (Robbins et al. 1989). The choice of nest sites which are far from paved roads has also been corroborated by Kostrzewa (1989). Nesting close to valley bottoms may be due to the fact that most pasture and crop lands are found there, both of which are favorite hunting grounds for Common Buzzards. Reliance on open areas for foraging may also explain why Common Buzzard nest sites are often near forest edges (Tubbs 1974, Knuwer & Loske 1980, Weir and Picozzi 1983, Goszczynski 1985, Jedrzejewski et al. 1988, Kostrzewa 1989, Hubert 1993, Hohmann 1994, Graham et al. 1995). Open areas may also be needed because they facilitate courtship behavior. Development of higher temperatures and upward thermal air currents over open habitats (Cone 1962, Jedrzejewski et al. 1988, Cerasoli and Penteriani 1996) may enhance courtship flights when pair-bonding takes place in the early part of the nesting season. Nest-site selection near forest edges may also be attributed to ease of access to nests and to a need for an unobstructed view of the surrounding landscape (Roché 1977, Hubert 1993).

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